AVIATION AND AIRCRAFT JOURNAL

NOVEMBER 29, 1920 VOL. IX. NO. 11

Member of the Audit Bureau of Circulations

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THE GARDNER, MOFFAT COMPANY, Inc., *Publishers*

HIGHLAND, N. Y.

HARTFORD BUILDING, UNION SQUARE, 22 EAST SEVENTEENTH STREET, NEW YORK

SUBSCRIPTION PRICE: FOUR DOLLARS PER YEAR. SINGLE COPIES FIFTEEN CENTS. CANADA, FIVE DOLLARS. FOREIGN, SIX DOLLARS A YEAR.

ISSUED EVERY MONDAY. FORMS CLOSE TEN DAYS PREVIOUSLY. ENTERED AS SECOND-CLASS MATTER MAY 19, 1920, AT THE POST OFFICE AT HIGHLAND, N. Y., UNDER ACT OF MARCH 3, 1897.

AVIATION
AND
AIRCRAFT JOURNAL

Vol. IX NOVEMBER 29, 1920 No. 11

Flight Instruments

THE importance of proper flight instruments is not sufficiently appreciated by the average pilot in this country. There are a few who have done a great deal of flying in low visibility areas but the majority feel that any instrument added is just so much more trouble. Regular flights on a commercial or mail airway require a great deal of flying when the visibility is extremely low in order to keep up with the schedule. The magnetic compass is a hindrance instead of an aid when flying in clouds or fog as it oscillates for a time after a change of direction. An attempt to keep a straight course by its aid usually results in a stall unless the pilot has had experience in this type of flying and allows for the oscillations of the compass needle.

In the last few years there has been a growing tendency to furnish inclinometers with machines. The majority of these instruments depend on the acceleration of gravity and hence are acted on by other accelerations in the machine. The result is that they indicate zero in normal flight, whether rectilinear or circling, and instead of indicating the inclination with respect to the earth they show the deviation from normal flight. These instruments are very valuable for this reason and pilots should use them, instead of expecting them to do impossible things and when they don't, entirely disregarding them.

A turn-indicator is a necessity. To supply the demand three general types have been evolved; those depending on the difference of speed at the opposite wing tips, those depending on the movement of air in a tube parallel to the lateral axis and those employing a gyroscope. They all have peculiarities but greatly increase the safety and economy of flight; they increase the safety by tending to prevent tail-spins; when in clouds or fog and they increase the economy by enabling the pilot to keep a straighter course and so consume less fuel and make better time in flying from one point to another.

A greater appreciation of the value of flight instruments by pilots would assist those that are trying to develop them and tend to increase the confidence of the public in aviation by greatly reducing the danger of cloud flying. For night flying they are equally valuable.

Superabundance of Technical Data

IN the early stages of airplane design, the great difficulty for the designer was to secure sufficient technical data, whether structural or aerodynamic. Wings on which exhaustive tests had been made were few in number. Propeller tests in the wind-tunnel were available in only one or two instances. Structural analysis had not been checked by numerous sand tests.

During the war an enormous amount of data was accumulated, but was maintained confidential. At the present moment it is gratifying to know that the release of all the information accumulated during the war, the results of a tremendous amount of experimentation have become available generally.

The difficulty for the engineer now is not so much to collect technical data as to index it and have it carefully on record without being swamped by its quantity. Moreover, there is a tendency to place an exaggerated value on technical data as such. In the long run a few fundamental principles and records will emerge, which the designer will carry around in his head or in a pocketbook, and which will constitute his entire technical stock in trade. Designing will remain a matter of art and not a matter of records.

The Trophy Room

NO visitor to Washington who is interested in the history of the Air Service should miss a visit to the new Trophy Room adjoining the office of the Chief of Air Service. No description can do justice to the array of trophies and portraits already in place. They reflect the fighting spirit of the Washington front. The Secretary of War is surrounded by forty immortals, only four or five of whom have wings. The names of Rickenbacker, Luke, Campbell, Thaw and Lufberry will probably be added soon, together with others whose names will ever be an inspiration to the next generation of fliers.

The standard of flags, too, have an impressive appearance. Here can be found the unspotted battle flag of the First Provisional Regiment of the Spruce Division. Visitors may consult the Freer Report for information as to its part in the winning of the war.

If a Trophy Room is to be maintained, it is to be hoped that a serious attempt will be made to have it representative of the achievements of our work in the air rather than on the ground.

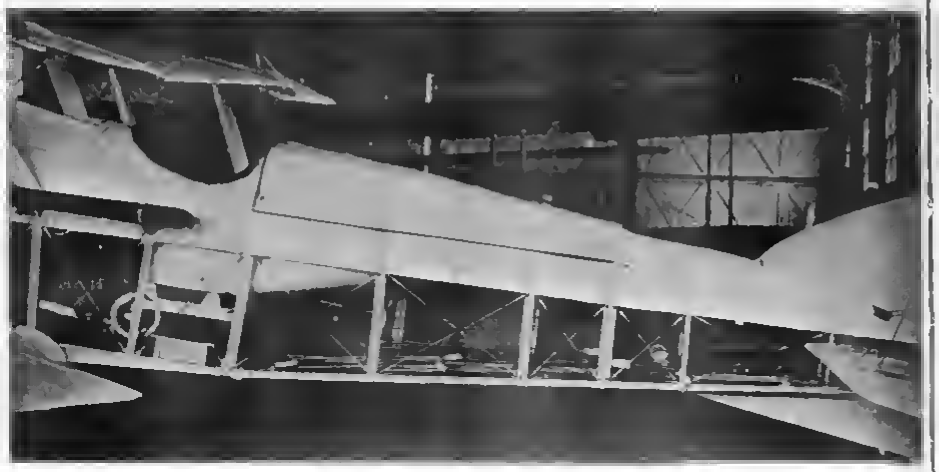
The Indiana

NOT much information has been given the public by the Navy as to the effect of the aerial bombardment of the old battleship *Indiana*. Beyond the fact that she was used as a target for two days and sunk, nothing is known. Probably such information may properly be considered secret, but when the matter of appropriations comes up in Congress, it is to be hoped that the tests will be inquired into and their results made known. That the aerial bombardment had remarkable success is believed by all who have confidence in the destructive power of air-bombs. It is true, that a ship of the *Indiana* class is more vulnerable than the present super-dreadnaught but the aerial bomb and torpedo have not as yet been developed to their maximum usefulness.

Those who have had wide experience in air fighting have the utmost confidence in the power of aircraft to disable naval vessels. It is a problem which will press forward during the next few years with increasing insistance.

The Van Meter Parachute Release

The general trend of parachute design has been to have the wearer jump from the aircraft. The parachutes as far developed function well when the wearer is able to jump so that he and the parachute clear the machine. During a spin or other evolution occurring when the machine is out of control, the aviator cannot very well walk out on the wing and if he attempts to jump from the cockpit there is considerable danger of fouling the tail. Also in case of fire or injury from bullets or other cause, the crew may only have presence of mind enough to push a lever, probably not enough to operate some complicated mechanism. Time is precious when near the ground, and a quick operating device is necessary.



An SE-5 Fitted with Release Showing Rubber Cords and Cover Closed

Lieut. S. L. Van Meter of the Air Service has developed a parachute release designed to avoid these difficulties. It is entirely automatic in its action after a single release rod is pushed and in addition incorporates many safety features in its construction. It is applicable to all open cockpit machines and does not require a cannon or other unusual device for its operation. The jumper is lifted from his seat and carried clear of the machine even if he is unconscious.

The illustrations herewith show an SE-5 fitted with the Van Meter parachute release. The installation does not interfere in any way with the normal operation of the machine nor does it add any head resistance. The weight of the device is about 30 lb. All of the apparatus is behind the seat under the turtle back in the space that is not normally in use.

The operation of the release, as stated above, is entirely automatic after the release lever in the cockpit is pushed. The handle is protected by a guard in order that it may not be accidentally pulled and so remove the operator from the machine without cause. This would let the machine go unattended while the operator slowly floated to earth.

The principal change involved is a reconstruction of the fuselage cover (turtle-back) from the rear of the seat to the front of the fin. The turtle-back is hinged in front of the fin and held in place by a latch at the back of the seat. The movable portion consists of a wooden grating that rests on the longerons, the usual curved portion being split in the middle. An extension of the grating is under tension from rubber cords through a cable running over a pulley. When the latch is released the rubber cords contract, rotating the turtle-back about its hinge; the halves of the curved cover are separated.

When the turtle back has rotated through 80 deg. the force of the wind carries it back until it rests on the fin and the rubber cords, due to the position of the pulley, now act in shock absorbers to prevent the grating from hitting the fin too hard. An ingenious arrangement prevents the rubber cords from pulling the cover back should the wind speed drop due to a stall or other cause.

It operates as follows: The extension of the grating is slotted and the cable going to the rubber cords is fastened to a T-shaped piece. When the turtle-back has nearly finished its revolution, this T-piece slides up the slot and so puts the pull of the rubbers directly on the hinge.

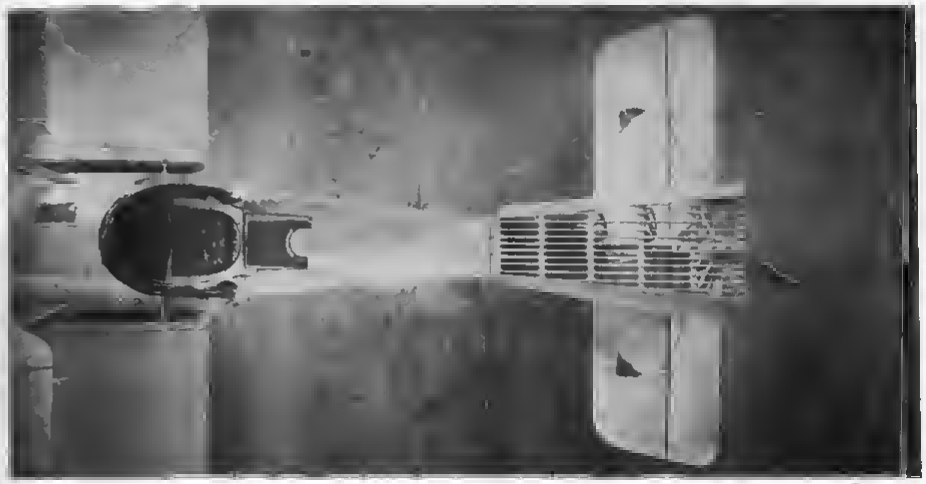
The space in the fuselage from the rear of the seat to the hinge is fitted with a smooth trough which extends from the seat proper to the hinge and so connects with the grating which is now resting on top of the fin. The back of the seat drops back into the trough and in doing so releases the safety belt. The belt is normally held by two hooks fastened to the seat and extending into the back when it is vertical. When the back of the seat drops, the points of the hooks are uncovered. The operator, when pulled out through the trough, automatically pulls the belt off the hooks.

The operator is pulled out of the machine by the parachute. The parachute is carried in a special case fitted at the end of the grating, that is to say, it is at the back of the seat before the release is pushed. This case is arranged to let the air blow through it when the grating is back. The parachute opens behind the machine and shock absorbers in the cords prevent the pull on the operator from being too abrupt. The case opens out and falls back automatically under the action of rubber cords.

If desired the standard back pack may be worn. The operator is pulled backward from the seat along the trough and grating and so out and clear of the machine. The grating, resting on the fin, prevents any interference with the empennage. The two halves of the cover rest on the bracing wires and act as further guards against fouling.

While this device is especially suitable for military work it can be utilized on civil aircraft having open cockpits. There will always be many of the sport type of machine flying around, despite the fact that commercial machines will have enclosed cabins for reasons of comfort and efficiency.

This is not the first design of parachute that Lieut. Van Meter has produced but is the product of an evolutionary series. A former design was described in Aircraft Journal for February 14, 1920.



The Cover Thrown Back Showing the Clear Path for the Jumper

An Air Transport Record

Records of air transportation companies in Europe for safety in carrying passengers are more than matched by the performance of Aero Ltd., of New York and Miami, Fla., during the past ten months. In the 10 months from January to October, inclusive, this company has carried 4,500 pay passengers without a single accident to a passenger in their six HS-L Liberty engined flying boats. These operations include the winter season of 1920 where from their base at Miami they operated along the Florida coast and between Miami and the islands of Bimini and Nassau, and the past summer season operating from New York to Newport, Atlantic City, Albany and other coast and river points.

Two of the Aero, Ltd. flying boats, seating six people each, left New York for Miami, Fla., on November 11 for the coming southern flying season. Among the passengers carried were Leland Sterry, manager of the Grand Union Hotel at Saratoga Springs and the Breakers at Palm Beach; the Misses Edith Gordon and Rose McDonald of New York; John Hampton Cooper, R. T. Bellchambers, Miami representative; W. A. Reagan, Nassau representative. The Two boats, Nos. 7 and 8 of the Aero Ltd. fleet were piloted by Harry Rogers and Duke Schiller, respectively.

In the near future Aero Limited's new fifteen-passenger twin-engine flying boat, piloted by Lieut. Alexander will leave for Miami. This will be known as the Amalgamated Flying Salesmen's Special. Ten representative firms of the North have engaged accomodations on this boat for their salesmen and merchandise. The boat will make stops at all of the principal cities on the Atlantic seaboard between New York and Miami. Arrangements have been made to have members of the Chambers of Commerce and leading merchants of these towns meet the salesmen and representatives on their arrival.

This addition to the Aero Ltd. fleet is one of the large Navy F-5-L twin-engined Liberty boats. The boat was rebuilt at the Philadelphia Navy Yard for passenger service with enclosed cockpit, wicker chairs and accommodations for 15. It will go into the Miami, Nassau, Bimini service.

There have been previous flying salesmen's trips but they were individual and of short distances only. This will be the first time in the history of commercial aviation that an "Amalgamated Flying Salesmen's Special" has been attempted. The salesmen will report their sales back to their firms by wireless, the plane being equipped with a radio instrument and a competent operator in charge.

A certain number of private passengers will also be carried. Heretofore the rates between New York and Miami have been so high, in the neighborhood of eight hundred dollars, that the idea of flying down for purely personal reasons was prohibitive. At the reduced fare of two hundred and fifty dollars per passenger a full complement has been assured.

Detroit Club Election

Lew W. Kunze was elected president of the Air Service club of Detroit at a meeting in the Army and Navy clubhouse, Jefferson avenue and Rivard street, November 10. George H. Stimson was chosen vice-president, and George W. Wooley, secretary and treasurer. The executive board for the ensuing year will be as follows: R. B. Fish, J. Gordon Rankin, George Wilcox and Henry M. Lumb.

Belgian Aero Technical Laboratory

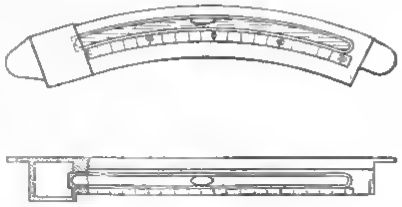
By Belgium decree, there has been created an aero technical laboratory. This laboratory will be under the direction of M. E. J. Allard, pilot who has had experience under Eiffel at Paris and since then has directed the installation of the King Albert air way in the Belgium Congo.

Airplane Flight Instruments*

By Kurt Bennewitz

The task of watching the position of his airplane in space, occupies the pilot continuously, whether consciously or unconsciously He does this generally by eye and by feel, and his eye is generally the more satisfactory guide. When his eye fails him, as in fog or on a dark night he can only rely on feel, and in such a case even a good pilot may feel at a loss.

The problem of securing independence from such untoward conditions is extremely important. To help out the "feel" of the pilot a number of instruments are in use, whose success depends not only on their indicating qualities, but also on the measure in which the pilot is able to read them. Such instruments may be termed "flight" instruments.



FIGS. 1 AND 2

The failure of flight by "feel" is due to the fact that "feel" does not supplant the need of a system of axes of reference. Such a system of reference is provided by the earth, or rather by the horizon, another system is that of the axes of the plane itself, which although not visible, is felt by the pilot by means of the effects of acceleration.

Inclinometers with a Stationary System of Reference

To this class belong in the first place, all the pendulum type of instruments whether of the rigid or liquid pendulum type.

A pendulum may swing in one plane only, and be employed at will either as a longitudinal or as a lateral inclinometer Or it may be free to swing in two planes and give both longitudinal and lateral inclination.

Every pendulum may oscillate and this increases the difficulty of its use as an inclinometer The oscillation must be damped either by air, liquid or more rarely by magnetic or electrical eddies, so that the pendulum may give a correct indication almost without swinging In practice damping can be made just as large as desired. But the greater the damping, the slower is the pendulum in giving a reading The amount of damping given is therefore a compromise The solution of the problem is somewhat helped by the fact that for the airplane angular oscillations are not too rapid. Experiments have indeed shown that even strongly damped pendulums are sufficiently rapid in their action on the plane.

It must be noted that with decreasing temperature, the viscosity of fluids decreases considerably Calibrations should be made therefore at the lowest practical temperature, say—40 deg C

It is not advisable to try and build instruments whose period of vibration is infinitely small, either through combination of several pendulums with varying degrees of damping or in any another manner, since this is practically impossible of solution.

The most useful liquid type instruments are those shown in Figs. 1 and 2, in which the inclination is given by means of an air bubble. There exists an important difference between this liquid type and a rigid pendulum. If the instrument is inclined to the left, the bubble travels to the right. With a rigid pendulum, if the plane is inclined to the left, the pendulum swings to the left. This must be duly taken into account by the pilot.

The inclinometer of Fuess, shown in Fig 3 gives a displacement corresponding to that of a rigid pendulum and good damping A small ball runs in the liquid. By changing the

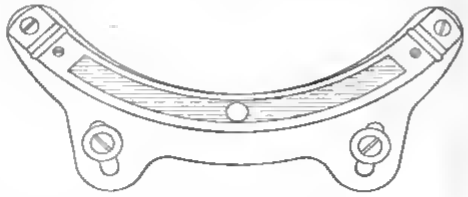


FIG 3

liquid and the size of the ball, the damping can be varied at will By changing the curvature of the vessel the sensitivity can be altered.

All pendulums have the common property that they take up a position which corresponds to the resultant of all the forces in action, including acceleration. At rest or in regular straight line flight, whether horizontal or inclined, this position corresponds to the true vertical. But this is not true for accelerated or decelerated flight, or on a curve On a curve there are appreciable lateral accelerations, so that the plane itself takes up a certain position away from the vertical; yet the pendulum gives no indication on a correctly executed curve But the correctly executed curve is a normal condition of flight, just as is rectilinear flight. If in such a maneuver the pendulum, gives no indication of a change of position to the earth's vertical, it serves therefore to indicate a normal flight condition

Instruments depending on the pendulum principle may however be said to give indication of position of space only conditionally, as explained above Pilots are not entirely satisfied with the lateral inclinometer and demand a true inclinometer which would work correctly in circling flight

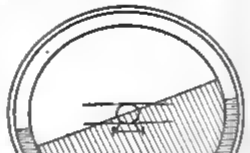


FIG 4

The solution of this demand places a much greater load on the construction. It has been sought to solve the difficulty by using neutral pendulums, supported at their center of gravity; also by the use of balanced streamline forms All these types fail however because of friction which can never be avoided. The only instrument based on this principle used at present is that of Anschuetz shown in Fig. 4. This inclinometer should when well constructed maintain its vertical position independently of curves or accelerations. Practice has shown however that this is only true for a short time, and only for curves of a large radius. With turns of some duration however, it moves away from the vertical little by little, and its usefulness ceases. It is not impossible that this instrument may be technically improved.

All other fields of force, other than gravity, in relation to which the inclinometer might be built are either too weak or too undecided, as for instance the magnetic field. It is also conceivably possible that from a measurement of acceleration, the presence of a curve might be deduced. Such attempts have been made, but have failed through as rise and fall of the plane as well as gusts have totally annulled the acceleration effects. Further it may seem possible to obtain an inclinometer with help of the magnetic inclination in connection with the ordinary compass, but attempts in this direction have failed.

Recently instruments have been built which embody a turn measuring instrument with a pendulum inclinometer, and together provide a complete substitute for the absolute inclinometer. As the pendulum is equal to all demands which are imposed upon it in normal flight, it need only be connected with an instrument which indicates on what curve the airplane is flying

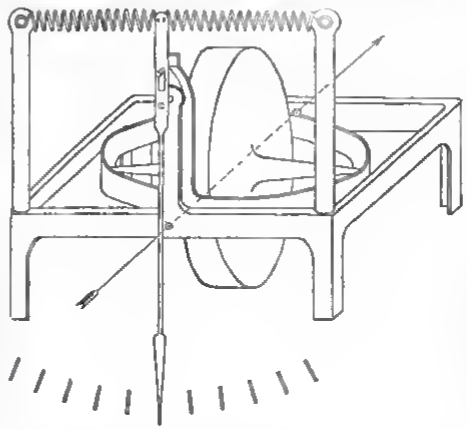


FIG 5

An instrument indicating the curve on which the plane is flying is the Drexel turn indicator, shown in Fig 5 It includes a gyroscope which has not three degrees of freedom, but only one and a half, having movement about one axis free, and movement about another axis restrained by a spring With changes of direction, the gyroscope does not maintain its vertical position, but is forced to change its position in proportion to the intensity of the turn, and its precession is taken up by the spring. The instrument effectively indicates the curve which the airplane is making about its vertical axis, not the angle of bank or the angle of incidence. Except for temporary disturbances of its always delicate system, it has worked very well, and has been generally introduced on large airplanes.

If the action of this turn indicator is compared with that of a common compass, the main difference is that the compass indicates the deviation from a fixed direction, while the turn indicator, gives the angular velocity. It follows that every good compass can be used as a turn indicator The advantage of the Drexel turn indicator lies in the fact that is is much more sensitive to changes in direction, and that it avoids the oscillations of the compass. It has its main use however only when it is proposed to read small changes in direction.

A compass has also been used, in which the angle of turn has been doubled by means of a mechanical device. Optical methods are an improvement on the mechanical increase of the movement.

A turn indicator in combination with two inclinometers gives a complete system of measurement, and the combination has been carried out in the Drexel instrument.

II. Inclinometers with a Moving System of Reference

These instruments do not show all inclinations, but they do give indications to the pilot which are perhaps more important

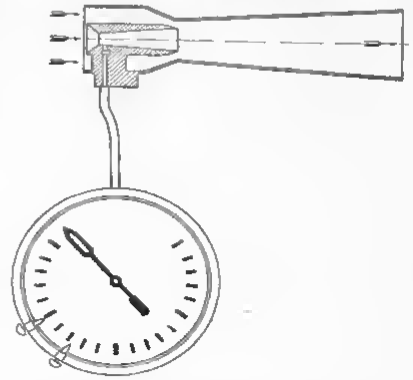


FIG. 6

than those of the instruments previously described. The airplane in the air, has apart from the ever present force of gravity, no connection with the earth, but a real connection with the surrounding air We refer flight conditions far too freely to the earth.

The inclinometer in the form of a pendulum shows the angle of incidence at which the airplane is flying, but does not indicate whether the angle is suitable or dangerous. The

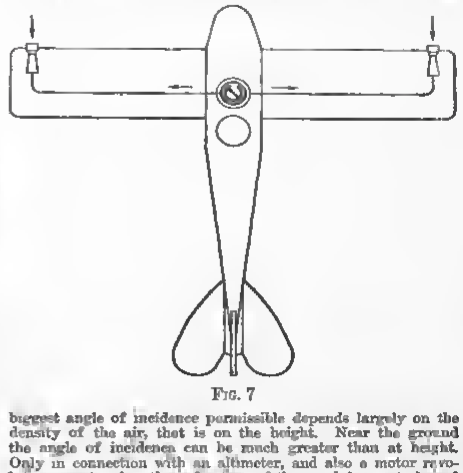


FIG. 7

biggest angle of incidence permissible depends largely on the density of the air, that is on the height. Near the ground the angle of incidence can be much greater than at height. Only in connection with an altimeter, and also a motor revolution counter, has the indication of the pendulum a technical value.

There are, so-called pressure speed indicators, which indicate

*Freely translated from *Technische Berichte*.

the pressure produced by speed of flight. These work with a Pitot tube, or Venturi tube. Lately a type of tube such as shown in Fig. 6, has come into use which is better adapted for practical use. These instruments have been used hitherto as speed indicators, which is not correct as long as their readings depend on the density of the air. In flight such an instrument is acted upon by the slightest rise or fall of the plane, owing to the consequent change in velocity.

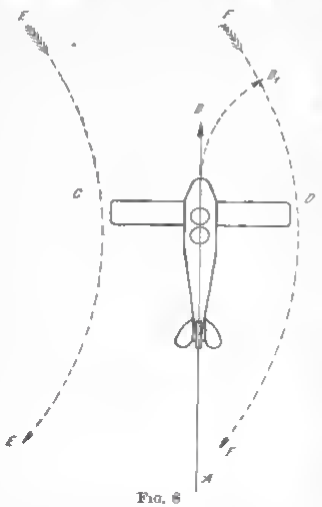


FIG. 6

Neither the speed nor the angle of incidence give the pilot an indication of his security in flight, which is given solely by the pressure of the indicating tube. For every machine this pressure has a minimum value, below which control is lost. The value is independent of the air density, that is the height, and only dependent on the loading per square foot. Thus minimum value can be determined by a trial flight and marked on the speed indicator. Speed indicators generally have two such marks, one for use in climb, with full open throttle, the other on a glide with motor throttled down. The difference lies in the air resistance of the slow and fast moving airscrew. The pressure speed indicator is therefore primarily a technical flight instrument to indicate security to the pilot and only secondarily a speedmeter. The pressure speedmeter can be used as a safety indicator therefore.

Similar considerations obtain for lateral stability. As a lateral indicator the pendulum shows not only the position of the airplane, but also its position relative to the danger of a side slip, and the normal position is such that the lateral inclinometer gives no indication. The lateral inclinometer can also be considered a safety device.

We will now consider the question whether the turn indicator can be used, dispensing with the earth as a point of reference. If an airplane describes, a turn in calm air, then the outer wing tip moves faster than the inner wing tip. The pressure on the outer tip is therefore greater. It has been attempted to measure the difference in pressure at the two tips and to obtain therefrom the magnitude of the turn.

There are involved not only the technical difficulties in obtaining sufficiently sensitive measuring instruments, and perfect symmetry of disposition, but also the possibility of air disturbances at either end of the wing annulling or augmenting the effect of the turn. In Fig 8 *AB* is the direction of flight, *CD* the ends of the wings; the dotted lines represent an air vortex of such a character that the airspeed along *EC* is smaller than along *FD*. Imagine the plane coming from *A* out of calm air in rectilinear flight and meeting the air vortex. There will be at *D* a greater air pressure than at *C*. This raises the tip *D* and retards it. So that the plane turns in the direction *B*$_1$.

The plane is now approaching a dangerous position. The indications of the instruments will be as follows:—

a.—The lateral inclinometer: A strong bank to the left reinforced by the centrifugal force of the turn.

b.—The pressure turn indicator: A left turn instead, of the actual right turn.

c.—The Drexel turn indicator: A right turn.

The use of instruments *a* and *b* would give the flier the impression that he had overbanked a left turn. As he would judge this to be dangerous, he would seek to diminish the overbanking and then to leave the vortex as quickly as possible by use of the rudder and a right turn. By a right turn he would correct the pressure drop at *C*, and his maneuver would be correct.

The use of instrument *c* would on the other hand give the pilot the impression of a right turn. He would probably counteract the right turn by rudder to the left, with the result that the dangerous position would be still further increased. Since the pressure at *D* would be still further increased, and the wing would sink still farther at *C*. At the same time the lateral inclinometer, through the enforced left turn would tend to show no displacement. The machine would be steered right into the vortex instead of avoiding it, and instrument *c* would give no indication of danger.

Thus instruments *a* and *b* would have been the cause of a correct maneuver in spite of incorrect indications. The instrument *c* in spite of seemingly correct indications would have led up to a false maneuver. A pilot who without a knowledge of what happens and only judges by eye would be always disposed criticize the pressure turn indicator. In this he would be wrong, for the pressure turn indicator must not be expected to replace a compass.

More important is the influence of the magnitude of the pressure on the turn indicator. The pressures at the right tip and left tip depend on the density of the air, and the difference in pressures depends on the air density likewise. If the plane describes equal curves in circumference and of the same angular velocity at different heights, the differential pressure gauge would show a curve of larger radius at the greater height, while it is in thinner air that a curve of equal circumference is more dangerous. The pressure turn indicater therefore fails as a danger signal. This can be rectified, however

If p_1 and p_2 are the two pressures, then is the danger proportional to $p_1 - p_2$ and inversely proportional to the total pressure, that is the mean value $\frac{p_1 + p_2}{2}$. As p_1 is very nearly equal to p_2, we can replace $\frac{p_1 + p_2}{2}$ by p_1 and say that the danger is proportional to $\frac{p_1 - p_2}{p_1}$ or $\frac{p_1}{p_2} - 1$.

So that $\frac{p_1}{p_2}$ is an indication of the danger.

An instrument can be readily constructed to give such an indication providing it reads log p_1 — log p_2. Whether by this modification, a perfectly successful use of the pressure turn indicator can be obtained remains to be seen.

If when in comparative testing of the pressure turn indicator and the Drexel gyroscopic turn indicator, the latter has shown up less favorably, this has been for smaller machines, because with large machine air vortices are of less importance. The case is similar to that of a small boat and a large steamer at sea. The boat is strongly acted upon by the waves and must be skilfully handled; the steamer scarcely notices the waves.

In conclusion, the following may be considered a satisfactory list of instruments to help the flier:

1. Lateral inclinometer
2. Longitudinal inclinometer in the form of a pressure air speed meter
3. Turnindicator

a. For large machines the gyroscopic turn indicator.
b. For small machines an improved form of the pressure turn indicator.

Some Experiments with Model Airplanes

By Albert A. Merrill

Aeronautical Department California Institute of Technology

Experiments have been made both in Eiffel's laboratory and in the National Physical Laboratory in England to determine the static stability in pitch for models with the elevator set in various positions. Since a machine is balanced to fly at one angle and speed, to alter the speed, the climb or the glide, the elevator must be displaced from its normal position and held

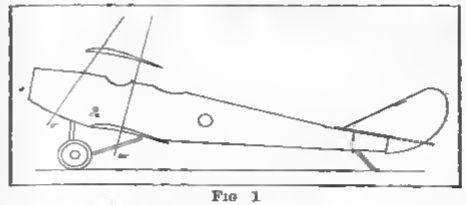


FIG 1

CURTISS JN-4; SURFACE, EIFFEL 36; $V = 30$ M P.H.; $VL = 6$

in its new position. Under these conditions the machine must be considered as a rigid body having different characteristics from those which it had when the elevator was in its normal position. It is essential to know what these characteristics are.

Some of Eiffel's reports may be found in "Nouvelles Recherches sur la Resistance de L'Air et L'Aviation" in the Atlas published in 1914. These reports show static instability in pitch with the elevator at a positive angle to its normal position; i. e. set for diving, for two machines of a type very common before the war. On page 252 of Cowley and Levy's book "Aeronautics in Theory and Experiment" the authors call attention to the fact that for a certain elevator setting there is, in some models, a region of instability. The experiments described below were made for the purpose of seeing if this unstable condition could be produced in a very common type of American flying machine, the Curtiss JN-4.

The model shown in Fig. 1 is not an exact copy of any machine, thus the tail is a flat piece of brass whereas in the machine it has a top camber. The model does however follow the main features which determine the aerodynamical characteristics such as surface used, overhang, size and form of body, size of tail, fin and rudder and setting of surfaces to body. Inasmuch as these experiments are made only to find out the rate of change of pitching moment with changes in elevator setting it is believed that such inaccuracies as may exist between model and full sized machine will not affect the value of the tests.

The model was tested for L, D and couple at the various angles shown in Fig. 2, under the following conditions: without tail, elevator, fin or rudder (pitching moment graph marked, *No Tail*) with tail, fin and rudder but no elevator (graph marked *X*); with the elevator at the various settings shown in Fig. 2, the angles being measured to the tail chord prolonged and minus signifying that the elevator is raised. In Fig 1 two vectors are shown for no elevator setting of zero degrees (the normal setting for tests) and a c.g. is marked on the vector for four degrees. Pitching moments are transferred from the spindle to this assumed c.g. but the scale is kept as measured, i. e. in pounds inches on the model at 30 m.p.h.

The first thing to note is that there appears to be no region of instability for this model. The next thing to note is that changes in elevator setting alter the stiffness somewhat. The mean slope of the — 15 deg. graph is about 17 deg. while the slope of the + 15 deg. graph is about 13 deg. Turning up the elevator increases the stiffness just as increasing the longitudinal dihedral between tail and supporting surfaces increases the stiffness though the former effect is not as great as the latter, the main effect of moving the elevator being to displace the graphs on the angle of incidence. Taking off the elevator is of course equivalent to reducing the size of the tail member and this decreases stiffness.

Thus agrees with other tests which have been made to determine change of pitching moment on angle of incidence due to change in the size of the tail members. (National Advisory Committee for Aeronautics, 1917, page 310). In this model

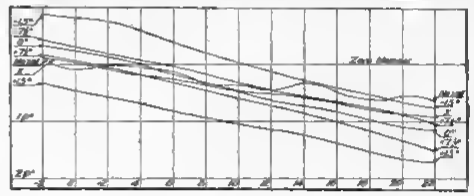


FIG 2

the rigid portion of the tail member (stabilizer proper) seems to dominate the situation to such an extent that there is no region of instability for any elevator setting and the stiffness is such that a movement of the elevator through 15 deg is required to alter the angle of incidence 6½ deg.

While for this model, stability would be maintained, therefore with elevator displaced for maintenance of certain angles of incidence, it does not follow that this would be always true and it would seem advisable to test machines for longitudinal stability, not only with the elevator in its normal position, but with the elevator displaced to a series of angles.

London-Paris-Toulouse-Rabat-Casablanca Route

British commercial interests in Spain and Morocco are manifestly of the highest importance and the rapid bi-weekly service by air, via London, Paris and Toulouse, cannot fail to be appreciated by mercantile interests. Letters and postal packets up to 6 2-3 ounces in weight are accepted by all French post offices at the following air fees in addition to the ordinary postage. Up to 20 grams 1 fr. 25; above 20 grams but not exceeding 100 grams, 2 frs. 50; above 100 grams but not exceeding 200 grams, 3 frs. 75. Envelopes and packets must bear the words boldly written "Par avion de Toulouse." Passengers are booked to Paris by the Handley Page Transport, Ltd., at the usual London-Paris air rates; it is then necessary to book from Paris by rail to Toulouse, as there is no air service at present between Paris and Toulouse. The fares from Toulouse are as follows:—

Toulouse to Barcelona, or vice versa	408	francs
Toulouse to Alicante	624	"
Toulouse to Malaga	1,008	"
Toulouse to Tangiers	1,320	"
Toulouse to Rabat	1,560	"
Toulouse to Casablanca	1 680	"
Rabat to Tangiers	456	"
Rabat to Malaga	648	"
Rabat to Alicante	1,032	"
Rabat to Barcelona	1,920	"
Tangiers to Malaga, or vice versa	696	"
Tangiers to Alicante	924	"
Tangiers to Barcelona	1,280	"
Malaga to Alicante, or vice versa	330	pesetas
Malaga to Barcelona	524	"
Alicante to Barcelona, or vice versa	330	"

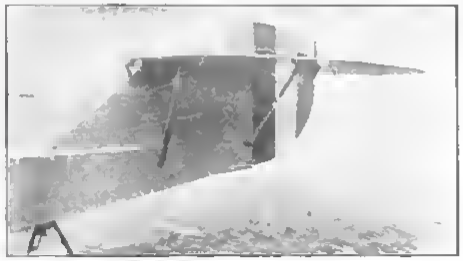
The above rates do not include insurance or hotel expenses. The machine leaves Toulouse at 9 a. m. and reaches Barcelona at 11 30 a. m. in time for lunch. The airplane leaves at 1 p. m. and arrives at Alicante at 4 p. m. Passengers dine and sleep at Alicante, the machine leaving there the following day at 8 a. m. arriving at Malaga at 11 30 a. m. for lunch. Departure from Malaga at 1 p. m. arrival at Tangiers at 2 p. m. and at Rabat at 4 30 p. m.

Sand Test of Flying Boat Controls

The following is a summary of the tests on the controls of an Aeromarine Model 40 Flying boat.

Construction of Control Surfaces

The ailerons are constructed similar to the wing. The front and rear beams are spruce of I-section White pine webs and spruce cap strips and trailing edge are used At the points



Tail Assembly

where the control horns are fastened the webs are reinforced by hard wood blocks glued in place. The ailerons are fitted to the upper wings only, have a total area of 58 sq. ft. and work in conjunction with each other, being interconnected by cables guided through streamline fiber blocks along the front edge of the upper wings. Each is equipped with two control horns with shackles to take both brace and control cables. The control cables run from a loop an the under side of the aileron to a pulley on the lower wing and thence, along the lower wing to the hall where the cables are led through tubes to the control bridge.

The horizontal stabilizer is attached by means of bolts to the edge of the vertical stabilizer The outer edges are braced by means of struts, made of steel tubing running to the hull, and cross wires. The stabilizer is set at an angle of one

Set-up for Stabilizer and Elevator Test

degree and a half from the line of the propeller axis. Area is 39 sq ft.

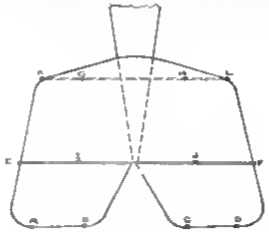
The elevator is constructed similar to the aileron with the exception of the trailing edge. This is made of streamline steel tubing bent to shape. Two horns are provided for control, and at the place where the horns are attached, the webs are reinforced by glueing on hard wood blocks. The elevators are of the unbalanced type, and each elevator has an area of 12.8 sq. ft; total 25 0 sq ft.

The rudder is of the balanced type. The frame is made of steel tubing welded together. The trailing edge is flattened to a streamline cross section. The lower part is made of wood, making it an efficient water rudder. The rudder is provided with two control horns, with brace wire running to the trailing edge. The area is 17.5 sq. ft.

The vertical stabilizer is built up of spruce beams, cap strips, and pine webs. The ends of the front and rear beams project into the hull These attach the stabilizer to the boat. The rudder fastens to the rear beam of the vertical stabilizer. The area is 15 sq ft.

Elevator and Stabilizing Test

The elevators and stabilizer were tested with the hull placed in an inverted position and the loading applied to the under part of the surface tested Elevators were canted up and held up as shown in photograph, this being the worst condi-



Elevator and Stabilizer Test

Deflection Table

Load sq ft Stabilizer	Load sq ft. Elevator	A	B	C	D	E	F	
5	5	2⅛	2⅜	8	8¾	½	⅛	
10	10	4⅜	8	8	4⅜	5/16	¼	
15	15	7	10⅝	7	8⅝	½	7/16	
20	17 5	8¾	12¼	6¼	10¼	⅝	9/16	
25	20	11	13⅝	5⅛	11⅞	16/16	⅝	
30	22 5	13¾	15½	10⅝	12¾	1⅛	⅝	
35	25	14½	16 3/16	13⅝	14	1¼	1	
40 7	27 5	16½	18⅜	15⅝	18	Stabilizer Failed		
	30 69	18⅝	20⅝	17½	18⅝			
	33 18	22	24¼	20⅝	20	Control Bridge Failed		

Deflection Table

Load sq ft. Stabilizer	Load sq ft Elevator	G	H	I	J	K	L
5	5	0	0	1/32	0	1/32	0
10	10	0	0	1/16	6/16	1/16	0
15	15	a	0	5/64	3/8	5/64	0
20	17 5	a	0	6/32	7/16	6/32	0
25	20	⅛	a	7/64	8/16	7/64	0
30	22 5	⅛	⅛	⅛	⅝	⅛	⅛
35	25	⅛	⅛	9/32	⅝	5/32	⅛

tion. The loading was done by means of sand bags which contained 5 lb. per square foot, which constituted a full load and 2½ lb. per sq. ft. which was considered a half load. The amount of loading applied to the surfaces was as follows:—

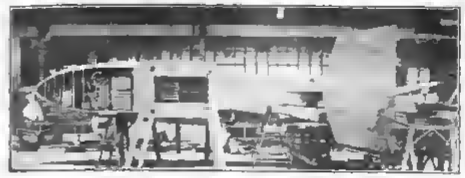
Stabilizer. Area 39 sq. ft. The total load required for a factor of safety of six or a load of 20 lb per sq ft. is 30 x 20 = 780 lb

Elevators The area of both elevators is 25.6 sq. ft and the total load required for a factor of safety of six, or 20 lb. per sq ft is equal to 25 0 × 20 = 512 lb

The total loads were applied in units of five lb. per sq. ft. until 75 per cent of the required load had been applied. The loading was then continued by adding half unit loads on elevator and full unit loads on stabilizer until failure occurred. Deflection readings were taken at various points at each load.

The elevator control system failed when the load reached 33.2 lb. per sq ft. The control bridge failed by buckling and let the elevators down until they were inclined at such an angle that no more bags could be applied. No other failure developed in the elevators or any other part of the control system except here-to-fore mentioned. The total load at failure on the elevators was 33.2 lb. per sq. ft. or equal to 849 9 lb. or a factor of safety between 9 2 and 9 96.

The stabilizer failed when the load reached 30.7 lb per sq. ft., the failure was caused by the webs crushing. The total load on the stabilizer at failure was 1776 lb. or a factor of safety between 10.5 and 12.2.

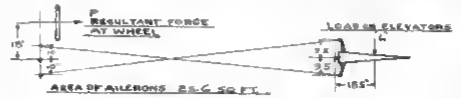


Set-up for Fin and Rudder Test

The factor of safety required for each of these surfaces was six.

Rudder and Fin Test

The hull, with the complete tail assembly attached, excepting elevators and rodder, was turned upon its side and suitably

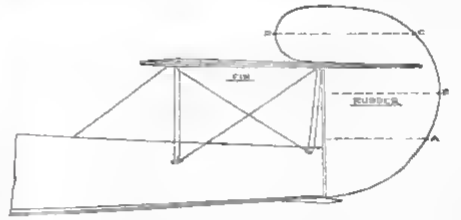


Elevator Control Test

Elevator Control Test

Load lb sq ft	Load in lb	Resultant Force at Wheel	Factor of Safety
5	128	128 5	1 50
10	256	378 5	3 00
15	384	414 7	4 50
17 5	448	484 0	5 25
20	512	553 0	6 00
22 5	576	622 5	6 75
25	640	691 0	7 50
27 5	704	760 0	8 25
30 7	785	848,0	9 21
33 2	850	918 8	9 95

braced to counteract the torque, due to the load on the tail surfaces. The foot bar was blocked by putting in a brace in such a manner as to lock the control system and all load applied to the elevators acted throughout the whole system. The loading for the rudder and fin was computed as follows.



Rudder and Fin Test

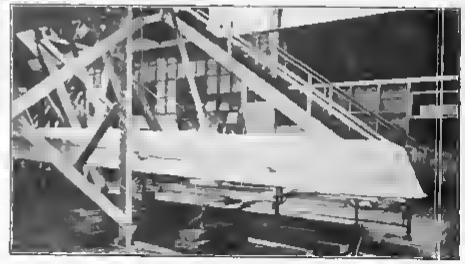
Deflection Table

Load sq ft.	A	B	C	D
5	2⅝	2⅝	2⅝	1
10	4	5⅛	5⅛	1⅝
15	1⅞	7⅝	7⅝	2⅝
20	4⅝	10⅝	10⅝	4
25	6⅝	18⅝	13⅝	5
25 5	Failure Occured			

Rudder—Area 17.5 sq ft. The total load required for a factor of safety of six is 15 lb per sq ft., or 17 5 x 15 = 262.5, the total load required to be applied to the rudder.

Fin—Area 15 sq ft. The total load required for a factor of safety of six is 15 lb. per sq ft. or 15 × 15 = 225 lb, the total load required to be applied to the fin.

The loading was applied by means of sand bags loaded 5 lb per sq ft. The rudder and fin were loaded in units of 5 lb. per sq. ft. until 25 lb per sq ft. had been applied, with the addition of one bag of the next load weighing 8.8 lb., the



Set-up for Aileron Test

rudder failed. After the failure of the rudder, the loading was continued on the fin until 70 lb. per sq ft. had been applied at which point the stabilizer failed.

The failure of the rudder occurred when the load reached 25 5 lb per sq. ft. by breaking the small cable leading from the horn to the trailing edge. The failure of this wire caused the cap strip to fail by tension and also caused the web at the horn block to fail by splitting Braces No. 10031 and No. 10032 pulled out from the joint at the horn block. The center web also cracked at the rudder post attachment point.

The balanced area edge of the rodder was sprung and showed permanent set after the load was removed.

The total load on the rudder at failure was 25.5 lb per sq ft. or 466 3 lb which is equal to a factor of safety of 10 2

No other failure occurred in the rodder control system except as herein mentioned.

Aileron Test

Deflection Table

Load sq ft	A	B	C	D	F
0	0	0	0	0	0
5	⅛	⅛	1⅝	2⅛	1⅛
10	⅜	1	3	4⅛	2⅛
15	⅝	1½	4	6	3⅛
17 5	⅞	2	5	7⅛	3⅝
20	1⅜	2¾	5⅛	7⅝	10⅝
22 5	1½	3⅛	6	8⅛	13
25	1⅞	3⅝	6⅞	9⅛	13¾
27.5	2	4⅛	8	10⅛	11⅛
30	3¼	4⅝	8⅛	11⅛	15⅜
32 5	Failure Occured				

The failure of the fin occurred when the loading reached 70 lb per sq ft.

The fin failed by two of the webs splitting at the lightening holes, however, the cap strip was not broken. At load No. 9 the upper web showed considerable deflection and at load No. 12 both webs buckled.

The total load on the fin at failure was 70 lb per sq. ft. or 1050 lb. which is equal to a factor of safety of 28.

Aileron Test

The complete machine was placed on staging erected for

the wing structure test in an inverted position. One aileron only was tested and the control wheel was locked in such a manner by running a bar through a hole in the gear wheel, the bar resting against the tubing of the control bridge, so that all loads applied to the aileron would act throughout the whole control system. The loads were applied in units of 5 lb per sq ft. for full loads and 2.5 lb per sq ft. for half loads. The amount of load to be applied on one aileron for a factor of safety of six or 20 lb per sq ft. was 580 lb.

The loads were added in unit loads of 5 lb per sq ft. until 75 per cent of the required load had been applied and then continued by adding half unit loads until failure occurred.

The aileron failed when the load reached 32.5 lb. per sq. ft. or a total load on the aileron of 942.5 lb. or equal to a factor of safety of 9.95

The failure occurred at the outer point of attachment of the aileron control loop due to the eccentric pull on the bolt to which the cable was attached. The wood block reinforcement split and broke the web and cap strip The control bridge was distorted about ¼ in. No other failures developed in the aileron control system.

Personnel Conducting Tests

The tests were made at the Aeromarine Plane and Motor Company's factory at Keyport, N. J. Fred Keller of the company's Engineering Department was in charge of the test, and Ensign Edmund A. Whiting, U. S. N. R. F. represented Lieutenant Alfred Bledsoe, Inspector of Naval Aircraft, U S N. All tests on the control surfaces were made in accordance with General Specification No. 100.

Summary of Tests

Breaking Required

Load Carried	Surface	Load lb /sq.ft.	Load lb /sq.ft.	F S. req	Factor Broke	of Safety Carried
30 7	Elevator	33.2	20	8	0 96	9.3
35	Stabilizer	40 7	20	6	13 2	10 5
35	Rudder	35.5	15	6	10 2	10
35	Fin	70.0	15	6	00 0	30
30	Aileron	32.5	20	6	9 9	99

The Model 40 Flying Boat controls are considered to have passed the sand load test successfully.

Needed: A Bureau of Naval Aeronautics

While the Hicks Bill creating a Bureau of Aeronautics did not pass at the last session of Congress, it is of such immediate importance to the development of Naval aeronautics that it is hoped that it will be taken up and passed at the coming session.

The following comment went with the Hicks Bill to the Committee of the Whole House:

The Committee on Naval Affairs, to whom was referred the bill (H.R 14123) to create a Bureau of Aeronautics in the Department of the Navy, having had the same under consideration report it to the House favorably with the recommendation that the bill do pass.

The committee believes that the creation of a Bureau of Aeronautics in the Navy Department will consolidate and coordinate under one head the various activities of the Department pertaining to the field of aeronautics, now scattered among the several bureaus and offices of the Department, and that it will in large measure prevent the duplication of effort.

At the present time Aviation exists as an office under the Chief of Naval Operations, the requirements of the service being provided for by the several bureaus.

The importance of aviation as an effective military arm, the value of which it is difficult to overestimate, warrants, in the judgment of the committee, the creation of such a bureau similar in organization to the Department bureaus already in existence. For the proper development of aviation it is essential that control be centralized in one bureau

The necessity for such an establishment in the War Department was recognized by the Military Committees of both the House and Senate and by Congress in the bill recently passed whereby there was created an Air Service as an independent arm of the Military Establishment.

The forming of such a Bureau is not a great matter It would require only a small interdepartmental change giving to the Director of Aviation an administrative and executive function. He could then have direct cognizance over the supplying of aviation material, the transfer of aviation personnel, and he could control the source of his information and statistics.

Naval aviation has outgrown the organization prescribed for its administration. The present Departmental structure is too loose jointed to be workable—greater unification is an urgent necessity

Aviation is still growing and it is at that stage of development where it needs a very special attention that the Navy cannot give it without congressional legislation.

The Director of Naval Aviation has an administrative or executive power whatever. He is simply the senior member of the Aviation section of the Planning Division of the office of Naval Operation. At the present time the Chief of Naval Operations is charged with the administration of Aviation, and he personally has to pass upon Aviation details. This makes the control of Aviation slower and more difficult than should be the case, for this officer not only is responsible for general Naval duties similar to those performed by the Chief of staff of the Army, but he is in addition charged with responsibility for all operations.

The Director of Naval Aviation being simply head of a sub-section of the planning division, is theoretically only supposed to be charged with the drawing up of aviation plans. Yet, as a matter of fact, because of the inadequacy of the present Naval Organization as regards a new arm, he is charged with responsibility for all aviation, in spite of which he has no proper machinery with which to work.

A legalized bureau with a definite organization that will permit the coordination of the important work confronting aviation would give to Aviation the place to which it properly belongs in the Navy. The technical aviation sections of all bureaus should be detailed under the Bureau of Aviation to avoid the delays and inadvertances caused through the great effort necessary to obtain concerted action.

It is not the plan to have the Bureau of Aeronautics take over all construction, engineering, etc., from the bureaus of the Navy Department who are equipped to handle these particular tasks efficiently and economically; but to form an organization to coordinate the work of the bureaus, that can coordinate Naval Aviation with the Army and civil aviation; that can disseminate helpful information to the Naval service and the world, and that can bring about proper aviation liaison with foreign governments, and that can exercise an administrative and executive function for Naval Aviation.

Aviation is new and is developing rapidly and attendant upon such development is the usual large amount of executive and administrative details. There are new regulations to make covering Naval aviation. There are new policies to lay down, and these policies must change from time to time as science of aviation develops. There is much information and assistance to be given to civil aviation. There is liaison to form with foreign governments. There is cooperation to be brought about between the Army and Navy in civil aviation.

The Bureau of Navigation handles Aviation personnel, the Bureau of Engineering handles Aviation engineering, the Bureau of Construction and Repair handles Aviation construction. The efforts of these bureaus should be coordinated in the office of the Director of Aviation.

Officers who handle aviation affairs in the various bureaus of the Navy Department are not as a rule Naval aviators. Aviation is a highly technical science and the Director of Aviation should pass on the great number of questions that come up in the various bureaus that require technical knowledge.

For the purposes of centralizing control and in order to give the Navy Department an Aviation organization competent to deal with corresponding organizations in the other departments of the Government, it is important that a bureau for the direct control of Aviation should be established.

Col. Charles DeF. Chandler Retires

Col. Chandler has been retired from the Army for physical disability after a distinguished career. He was born at Cleveland on December 24, 1873, and educated in the Cleveland public schools and Case School of Applied Science, E E. course At an early age he developed an interest in military affairs and in 1896 enlisted in the Fifth Infantry, Ohio National Guard, attending the weekly drills and two summer encampments.

While this regiment was mobilized at Columbus, Ohio, in the spring of 1898 on account of the war with Spain, Sergeant Chandler received an appointment as first lieutenant, Signal Corps, U S. Volunteers, and was assigned to the 11th Company, remaining until the muster out of the organization in May, 1899 The 11th Company was in Cuba from December, 1898, to May, 1899

The act of Congress of February 2, 1901, increased the Regular Army and upon passing the required examinations he received commission as first lieutenant, Signal Corps, U S Army. From April, 1902, to November, 1904, he served as commanding officer of the U. S. Army cableship *Burnside* which was operating in the Philippine Islands and during the summer months of 1903-4 engaged in laying the Army cables between Seattle and Alaska. Promotion to the grade of captain, Signal Corps, occurred during the summer of 1903

Col. Charles DeF. Chandler
Photo U S. Army Air Service

Col Chandler's first participation in aeronautics was a free balloon voyage from Pittsfield, Mass., October 22, 1906, which was followed by other trips and qualifications as free balloon pilot in the spring of 1907 (Aero Club certificate No. 8), the most notable balloon voyages being in October 1907, when with Major J. C McCoy as aide he was first winner of the Lahm trophy (476 miles) and a few days later he served as aide to Major McCoy in the international balloon races from St. Louis, landing on the shore of Chesapeake Bay after 38½ hours.

In addition to other duties in the office of the Chief Signal Officer, Captain Chandler was placed in charge of a new Aeronautical Division, created in August, 1907; this assignment involved the preparation of the specifications under which the first Wright airplane was purchased and tested for the Army and also dirigible balloon No 1 manufactured by Glenn H Curtiss and Capt. Thomas S Baldwin. During the summer of 1909 he served as a member of the War Department board which conducted the official trials and accepted the first military airplane, making his first airplane flight with Wilbur Wright.

Immediately after graduation from the Army Signal School, Fort Leavenworth, in June, 1911, he was ordered to College Park, Md., in charge of the Aviation School. (Airplane pilot certificate No 59 and Aero Club expert aviator certificate No 5) In May, 1913, he again sailed for the Philippine Islands for foreign service tour and continued airplane flying there until November, 1913, at which time he was assigned as Chief Signal Officer, Philippine Division.

After his return from the Philippine Islands in the autumn of 1915 his first assignment was instructor in the Army Signal School, Fort Leavenworth, which continued only until March 15, 1916, because of orders to serve as Signal Officer for General Pershing's punitive expedition into Mexico. That duty continued until the autumn of 1916 at which time he was assigned by the Chief Signal Officer of the Army to undertake the development of balloon service for the Army.

Fort Omaha, Nebr., had been abandoned for several years and the first project was to reopen that post, utilizing available buildings, balloon shed and gas plant as the first balloon school. The school courses had not begun when the United States entered the World War, but Major Chandler was called to Washington to organize a Balloon Section in that office as part of the Aviation Section, Signal Corps. He was promoted to lieutenant-colonel in June, 1917, and colonel August 5, 1917

He left Washington, October 24, 1917, for duty with the American Expeditionary Forces in France. He continued in charge of the Balloon Section, A. E. F., until February, 1919, returning at that time for duty in the War Department. Since his arrival in the United States, March, 1919, Colonel Chandler has been Chief of the Balloon and Airship Division. He was retired from active service on October 16, 1920

He was honored with the Distinguished Service Medal and is an Officer of the Legion of Honor (France)

Airplane Stress Analysis

A hand book of airplane stress analysis has been published as Report No 82, by the National Advisory Committee for Aeronautics. It was prepared in 1917, for the Chief Constructor of the Navy, Admiral D W Taylor, U. S N., and was primarily intended to aid those who had to make for the U. S. Government estimates of airplane stresses and factors of safety.

The text, written by Dr. A. F. Zahm, comprises three parts: Part I, being introductory, presents briefly the mechanics of materials and of elementary structural members; Part II treats of airplane wing stresses; Part III treats of body stresses.

The text is followed by Part IV, written by L. H. Crook, which gives in detail the numerical solutions of the illustrative practical problems presented in the text, and by use of the methods and equations therein formulated.

Finally in Part V, prepared by the authors jointly, are assembled the tables, formulas and descriptive diagrams illustrating the text, also the graphical solutions of many of the standard stress problems given in the text, and previously solved numerically in Part IV.

The whole work, comprising 70 pages, is compact and orderly, with only brief arguments or explanations; and assumes that the reader has had an average engineer's training in the mechanics of materials and elementary structures. It is a handbook and not a treatise.

Ignition from the Engineman's Viewpoint

By Capt. George E. A. Hallett, U. S. A.

Chief of Powerplant Section, Engineering Division, Air Service

It is intended to discuss ignition in this paper in a broad and non-technical way. The definition of the word ignition should be broad enough to include the complete functioning of the ignition apparatus, beginning from the point where mechanical energy is absorbed to generate current and ending with the completion of the working stroke of the engine. The ignition system includes the mechanical drive to the magneto or generator and the task imposed on the system is by no means completed when a spark has passed over the gap of the sparkplug. Ignition means the complete burning of the charge of gas in the cylinder at top dead-center, at the time the working stroke of the piston commences. The means employed to accomplish this result is the ignition system. In the present-day type of gasoline engine a spark produced by high-voltage electricity is almost universally used for ignition. This high-voltage electricity is produced by an electrical transformer. The transformer "steps up" the lower voltage produced from the source of current, which may be permanent magnets or a storage battery. Regardless of the source, the result must be efficient ignition if maximum power output per gallon of fuel is to be obtained.

To grasp the idea of what takes place in an internal-combustion engine cylinder, let us think of the whole program of events slowed down for the sake of convenience. Picture the combustion-chamber full of compressed mixture or gas, then a spark occurring between the spark plug points. A small flame is then started by the spark and spreads out radially from the spark-plug, somewhat as ripples spread out when a stone is thrown into a pond, but this flame, unlike the ripples, proceeds at a constantly increasing rate of speed. We speak of the speed at which the flame travels through the charge as the rate of flame propagation. Finally, the entire charge is ignited and this should end the program. This stage of the combustion should be reached by the time the piston is ready to start down the working stroke. All this program requires considerable time, therefore, in order that it may be completed by the time the piston starts down, it is very necessary to start the program by causing the spark long before the crank and piston reach top center. This is called advancing the spark. The result is that, during the first phase of the ignition, pressure is building up rapidly in the cylinder and causing a reverse torque or backward pressure on the piston and crank. This is obviously even worse than wasting power. To reduce the amount of spark-advance needed we must arrange to have the charge of gas much more rapidly. There are three principal ways to make the charge burn faster:

(1) If we can light the gas on all sides and in the center simultaneously, it will cause the charge to burn more rapidly, just as when, in burning a pile of brush, it burns faster if the torch is applied on all sides instead of at one point only. This is an argument for using more than one spark-plug per cylinder.

(2) If the spark continued through a much longer period and the gas could be agitated within the cylinder or rotated fast enough so that most of it passed the spark while the crank moved only a few degrees, we would have much the same effect as if the spark-plug ran around the edge of the cylinder, igniting the gas on all sides almost simultaneously. This is an argument for turbulence.

(3) The use of high compression pressures will cause the flame to travel through the charge much faster and will at the same time give us smaller combustion-chambers. This means that the flame will not be required to travel so far, and will also give several other advantages which will not be mentioned. The objection to using high compression is that it causes knocking or a detonation and frequently preignition.

Preignition and Detonation

Whenever, for any reason, some part of the cylinder such as a valve, spark-plug points or flakes of carbon become sufficiently hot, they will ignite the charge. Such ignition generally takes place much too early and long before the spark would occur. This is called preignition. Frequently preignition causes a flame to remain in the cylinder through the entire four strokes of the cycle, and generally causes a great drop in power. We have learned recently that hot valves seldom cause preignition, while hot spark-plugs frequently do cause it. When the compression of an engine is raised, the temperature of both the compression and the expansion strokes is raised. Preignition is, therefore, more likely to occur. When an engine is preigniting it will usually continue to fire more or less regularly for a moment after the ignition is cut off. Preignition must not be confused with detonation and knocking. They are two entirely different phenomena. Either one can lead to the other, but they seldom occur at the same time.

As mentioned earlier, the spread of the flame through the charge is progressive when an engine is running normally, but this is not the case when an engine is knocking. We have all driven a car up a hill in high gear when the engine is full of carbon and have encountered loud knocking or "pinking" in the engine. This we have lately begun to call detonating. When an engine is detonating the flame starts out from the spark-plug and passes through the charge progressively at first but, after it is for example half way through the charge, the portion remaining unburned has reached the critical temperature at which spontaneous combustion takes place and, as a result, it all explodes at once instead of progressively. This phenomenon is known as detonation and causes a sudden rise in pressure like a hammer-blow, which soon dies down again and does little work. This is an explosion in the true sense of the word. The pinking sound is believed to be caused by the pressure wave traveling faster than sound travels, thus causing a musical note.

Different fuels when mixed with air have different temperatures of spontaneous combustion and therefore detonate under different conditions. Kerosene detonates more easily than gasoline. The compression used in automotive engines is easily limited by detonation.

Two Spark-plugs per Cylinder

If the charge is ignited at several suitable points simultaneously, only comparatively small bodies of unburned gas remain during the last phase of ignition and therefore higher compression can be used without encountering detonation. Or, the detonations may be so small that they are not noticeable and cause no trouble. I saw recently a four cylinder L-head truck engine pulling a load at 500 r.p.m. and knocking badly. By throwing a switch, sparks were caused in additional spark-plugs in each cylinder. All signs of knocking or detonating instantly disappeared, and the engine ran very smoothly.

One bad condition which causes detonation is when a hot exhaust valve is in one side of the cylinder and one or more spark-plugs are in the opposite side. In this case the last portion of the charge to be ignited is being pre-heated by the hot valve, so that it reaches the detonation temperature earlier than it otherwise would, thus causing excessive knocking. I talked recently with a man who has a car equipped with a T-head Benz engine and asked him to cut out the ignition on one side of the engine and then on the other alternately, to observe which spark location gave the most knocking. The experiment showed clearly that this engine knocked badly when the spark plugs over the intake valve were used. In that case we had the hot exhaust valve helping to heat the last portion of the charge which was burned. This engine knocked only slightly when the plugs over the exhaust valves were used and when both plugs were used, the driver noticed much smoother running and some gain in power.

Doped Fuel

Mr. Kettering and Mr. Midgley have developed certain compounds at Dayton which, when put into gasoline or kerosene, raise the critical temperature of the fuel or the temperature at which detonation takes place. Such "dopes" are entirely practical to use and make practical the use of far higher compression in automotive engines, thus greatly increasing mileage and power output. When doped fuel is used, carbon becomes an asset instead of a liability because the carbon forms a partial insulation which reduces the amount of heat wasted into the water-jacket, and at the same time decreases the volume of the combustion-chamber and in this way raises the compression pressure.

At McCook Field, we recently tested a 5½ x 6½ in. cylinder with about 118 lb. per sq. in. compression, or a compression ratio of 5·4 to 1, and noted a gain in power in the use of four spark-plugs over one and also in the use of four over two spark plugs. The gain when using four spark-plugs was about 11·1 per cent, and in the second case about 5·7 per cent.

POWER RESULTS WITH FROM ONE TO FOUR SPARK PLUGS

Spark plug Location	Speed r.p.m.	Brake Load hp	Actual Brake horsepower	Brake horsepower corrected to 60° F.	Theoretical Brake Horsepower
One under intake valve, one under exhaust valve	1,800	85.5	96.0	4.5	411
One under intake valve	1,801	81.0	91.5	4.0	41.6
Two under intake valves	1,800	85.5	96.7	4.10	41.1
Two under intake valves, one under exhaust valve	1,801	85.5	98.8	41.4	45.6
Four spark firing	1,800	80.0	40.5	42.1	46.4

Throttle and speed constant, spark and load variable, barometer 28.72 in. of mercury.

The accompanying table shows the results. The first column is the speed at which the engine was run, the second is the brake load and the next is the actual brake-horsepower. The column next to the last is the only one we need interest ourselves in, it gives the corrected brake-horsepower. The number and arrangement of spark-plugs is shown at the left. The second line shows the minimum power, which is with one spark-plug under the intake valves. The third line shows two spark-plugs under the intake valves and shows some increase in power. The bottom line shows four spark-plugs firing and shows the highest power. These tests were made with due regard for the best spark-advance for each combination, and using various spark plug locations.

The universal test-machine on which the cylinder in question was tested is shown. It is a 5½ by 6½ in. four-valve cylinder, designed for use on an 18-cylinder engine. This engine is arranged to test almost any kind of cylinder, either air or water cooled. The compression is varied by raising the cylinder up or down, and we have also arranged one cylinder on which we can change the valve-timing while running, for experimental purposes. At present we are doing much interesting work in the development of air-cooled cylinders on these universal test engines.

In preparing an engine for use in the Gordon Bennett race, we changed the compression from 118 to about 100 lb. per sq. in., used an especially prepared or doped fuel, and increased the power of the engine more than 11½ per cent. The economy was also increased to a very great extent. I feel that, when such gain in power and economy is available by the use of high-compression and doped fuels, there can be very little doubt that these things will be used.

As most of the tests were made at constant speed, the amount of fuel drawn into the engine was the same in each case; therefore the specific fuel consumption was materially reduced by the use of multi spark-plugs. Also, it was very noticeable that the use of four spark-plugs eliminated the tendency in this particular cylinder to pink or detonate. I am convinced that even small automobile engines will benefit by the use of two spark plugs per cylinder if they are properly located, because this would probably permit the use of slightly higher compression, the ignition by one spark-plug would tend to burn the other one clean in case of fouling, and there would be less tendency to knock. So-called "strong" sparks, or well-synchronized multi-sparks, show a tendency to keep the exhaust valves cooler. This is due to lower exhaust temperatures caused by more rapid and complete combustion during the working stroke. The choice of number and location of plugs is an engine-development problem, but the ignition engineers must make good multi-spark apparatus available.

The advent of lower-grade fuels for automotive equipment has tended to make ignition uncertain, with the present ignition devices and spark characteristics. Higher compressions make ignition more certain, but present difficulties due to higher resistance at the spark-plug gap. The tendency toward the use of higher compressions is very marked and I venture to predict we will have compression as high as 160 lb. per sq. in., used in conjunction with special or "doped" fuels, in the near future.

Certain and Uncertain Ignition

In speaking of ignition being certain or uncertain, it is meant that the use of low-grade fuel tends to make the conditions occurring in the cylinder immediately after the passage of the electric spark between the spark-plug terminals uncertain as to the rapidity of flame propagation or completeness of combustion. When higher compressions are used, if the charge is ignited at all, it burns much better. Ignition conditions really do contribute to good or bad flame propagation and combustion in engine cylinders. For example, some kinds of ignition sparks frequently called "weak" may be tardy in igniting the charge. This usually results in irregular combustion or slow burning of the charge, and uneven impulses in the engine. Sometimes the good effect of a more suitable ignition spark is offset by bad spark-plug location or unsuitable spark-plug length. These conditions can cause much the same result as a so-called weak spark. A good spark, well located, tends to give prompt quick ignition with more complete combustion. It is believed that the use of stronger sparks, or multi-sparks properly synchronized can improve greatly the results obtained from the present types of engine. Of course, if multi spark-plugs are used and the sparks are not properly synchronized, the results are apt to be the same as from one spark-plug.

To explain further, we only have to carry this idea to a ridiculous extreme. Suppose we provide two spark-plugs and the spark occurs in one at the proper time and 40 deg. later in the other. Obviously, the one occurring late is too late to do any good in helping to increase the rate of flame propagation, therefore the results are the same as with one spark-plug.

Spark-plug Tests

At McCook Field we necessarily test a great many makes of spark-plugs and, because a very small percentage of these plugs will stand up in airplane engines, we arrange this test so that the poorest plugs are eliminated with the least expense. Our first test is a short one, in a single-cylinder Liberty engine. Most plugs either break or show serious preignition in this test, but those that pass this test are then placed in a multi-cylinder engine on a dynamometer, where the tendency to preignite and heat breakage can be noted. After this they are tested in the same engine on a torque stand, where they get the cooling effect of a propeller blast. During this test an attempt to foul the spark-plugs is made. This test is also a check on their durability, to make certain that they will last long enough to make a flight safely. For this torque-stand test they are placed in an engine installed in an airplane. This airplane is then flown up to a 10,000 ft. altitude and dived down to a low altitude repeatedly, to further test the liability of the plugs to foul. When all of the foregoing tests have been completed, the plugs are used in regular flights until a 100-hr. endurance record has been made. Thus far, only about three American makes of plug have passed these tests and are good enough for service.

We are now experimenting with the Midgley indicator for accurately determining the presence of preignition. We find that preignition frequently burns off spark-plug electrodes in high-compression engines, but it is interesting to note that the use of dope in the fuel eliminates this trouble.

Recently I put a standard Liberty engine on a torque stand, to run with ordinary automobile gasoline, to ascertain how much trouble would be encountered. The first trouble was this burning-off of spark-plug electrodes. Incidentally, we found that the pistons were cracked, due to preignition, but, when

we used dope in this same fuel, we obtained almost the same power we would get with high-test gasoline and no longer burned off the electrodes.

Spark-plugs should be made to withstand even higher compression without causing preignition from unw on. Preignition is now conceded to be equally as serious a condition as fouling, if not more so. Almost all automobile spark-plugs will preignite in an engine with a compression of 118 lb per sq in. I believe, therefore, that spark-plug designers will have to do considerable development work. Perhaps much smaller spark-plugs would cool better than the present standard size, and perhaps plugs can be made which will contain no cavity to hold gas and cause preignition by over-heating it.

A spark-plug was submitted to us for test late last year, in which there was no cavity for the gas to enter. The plug might be pictured as having merely a round knob on the end which, if polished with sand-paper, would show a narrow strip of mica around the side of the domed end. The spark was supposed to jump across this strip of mica. These plugs were hand-made by a farmer down in Arkansas and were of such poor material that they would not stand up, but I considered the type interesting because it was entirely closed. I believe that the electrode could be run hotter without causing preignition.

Mechanical Defects in Ignition Systems

We now have many automotive engines developed to a point where stoppages due to failures in the basic engines are exceedingly rare. Most stoppages are due to clogging of the gasoline feed, or to ignition troubles. There was a time when we had many troubles such as valves sticking or warping and burning out, piston-rings breaking, etc., but most of these have been eliminated. We would now like to see the same thing accomplished in ignition apparatus.

I know of no case in which ignition engineers have gone to extremes in the strength of the spark and therefore I do not see how the present limitations of spark strength, duration, etc., were reached. It occurs to me, for example, that it might now pay to make ignition apparatus so that it delivered sparks perhaps three times as hot as those now in use and to design spark-plug points to withstand this high tension. It might thus be possible to keep spark-plugs clean when the engine is idling, due solely to the heat of the spark. Also, it might pay to let the spark continue through perhaps 40 or 50 deg of crank travel, so that it could ignite any unburned gas that might sweep by the plugs during the burning of the charge.

We are approaching the point where ignition apparatus is cramping engine design. The voltage and other characteristics of present sparks are becoming part of the limiting factors in the compression pressures and, therefore, in power and economy. Also, ignition apparatus is helping to limit the cheapness of fuels which we can use and still be able to start engines and run them under idling conditions.—*Journal of the Society of Automotive Engineers.*

European Nations Encouraging Commercial Aviation

"All Europe is working secretly trying to develop planes with which to dominate the air," according to C. L. Egtvedt, Chief Engineer for the Boeing Airplane Company, who returned Nov. 3, on the White Star Liner Olympic, after visiting all important aircraft factories in Great Britain, France and Germany. It was Mr. Egtvedt's opinion that there is nothing in Europe in the line of airplanes that Americans cannot duplicate. "In fact," he said, "many radical forms of construction on which they are now experimenting were tried out in this country some time ago and discontinued as not being worth the money required to develop along those lines at that time."

"While European Governments are experimenting with all types of airplane design, Great Britain appears to be doing more than the others and Germany is getting along very well experimentally but is handicapped in producing machines because of terms imposed by the Allies. Wherever I went in Europe I found aircraft operating. The public generally is interested in flying but there still are many people who hesitate to leave the ground. I was well received in Germany and aircraft manufacturers there expressed a desire to co-operate with America and do business generally with American concerns."

He said that the British Air Ministry in which are co-ordinated all branches of the Government dealing with aviation, feels that there is a wonderful future for aircraft and that it is approaching rapidly.

"British manufacturers and inventors are getting considerable support from the Government," said Mr. Egtvedt. "At the Air Conference just held in London civilian and Governmental reports were produced, indicating intense interest in England concerning the development of airplanes commercially, not only in Great Britain but throughout the world. There is no fact concerning aviation that the British Air Ministry does not secure and place at the disposal of British subjects.

"It was interesting to learn that $1,000,000 worth of freight has been transported by airplane out of the United Kingdom this year. This freight was carried in cargo planes to France, Belgium, Denmark, Spain and Holland. Planes coming into England from the continent carried $2,000,000 worth of imports. Airplanes operating to and from the British Isles in the last 15 months made over 48,000 flights, or in other words, travelled more than 1,000,000 miles, carried 32,000 passengers and more than 200,000 pounds of freight. As regards the safety of commercial flying, it was proved that the danger is slight, by a carefully kept record it is shown to be less than almost any other method of transportation. For example, in the last 15 months there was only one fatality for every 40,000 passengers carried. There was only one accident to every 34,000 miles of travel or, an average of one to every 1500 flights.

"This last year 1325 airplanes have arrived from the Continent and landed passengers and freight in Great Britain. They included 1079 British machines, 236 French planes, 9 Belgian and 1 Swiss. The planes departing from Britain for the Continent aggregated 1455. Of these 1206 were British, 341 French, 7 Belgian and 1 Swiss. In analyzing conditions, however, the Air Ministry credits the United States Air Mail as being the most successful mail service on earth. All the European Powers are developing their air mail services. Airplane travel in Europe is reasonably inexpensive. Comparative passenger rates between London and Paris prove just why persons like to fly that trip rather than make the journey by rail and steamer. I flew from London to Paris in three hours. By rail and steamer it would have taken all day. A round trip by airplane between London and Paris costs £18 while by rail and steamer it is about £8. One way costs £10 by airplane, £4 by rail and steamer. Freight by airplane is cheaper than the old method, parcels and other small packages costing 1-3 penny a pound by airplane and from 4 pence to 1¾ pence a pound by the old method.

"Interesting as these figures are, they only show what is in the public mind in Europe. The transportation companies, it may be said, are operating at a profit, or at least, maintaining a scheduled daily service without losing their capital.

"By analyzing conditions and guiding thought along structural and economical lines the Air Ministry has enabled the British airplane industry to maintain its factories, conduct experiments on new machines, produce all sorts of safety apparatus, and provide plans by which a successful transportation service may be conducted.

"The Air Ministry also makes available for general use information on trade conditions, opportunities and problems in all countries. The British hope by this method to establish their airplanes in foreign markets, principally in their colonial possessions and in South America. In this work of trade expansion which it is intended, will develop an aerial commercial fleet bearing the British flag, the Air Ministry performs a duty otherwise impossible, were Government and civilian aviation divided into a number of bureaus and departments, each operating independently, and not knowing what the others were doing."

Pressure Gages for Airplanes*

There are three systems of gasoline feed in use on airplanes:

(1) *Gravity*, in which the flow of gasoline to the carburetor is maintained by the hydrostatic pressure of the gasoline, the tank being higher than the carburetor.

(2) *Air pressure*, in which the air is pumped into the tank above the gasoline by means of a hand pump or a pump driven from the engine or by a small propeller and sufficient pressure maintained to assure the flow to the carburetor.

(3) *Pump force feed*, in which the gasoline is drawn from the tank and forced to the carburetor by a pump driven from the motor or by a propeller.

In systems (2) and (3) there may be an auxiliary gravity tank.

In system (1) no pressure gage is used.

In system (2) a gage is connected into the line of tubing

A B C

Fig 1. Air-Pressure and Oil-Pressure Gages

running from the pump to the tank, which indicates the air pressure maintained in the tank. A pressure relief valve is placed in the pressure line, which can be adjusted to blow off at any pressure. The maximum pressure used is generally 3 lb (sq in), but may be as high as 5 lb. (sq in.), without doing damage. The minimum pressure for satisfactory flow of gasoline is 1.5 lb. (sq in.). A serious objection to this system of feed is the fact that in the gasoline tank is maintained an explosive mixture of air and gasoline. Such a system is very objectionable on a combat airplane, for even if the tank is not exploded by the penetration of a bullet, the hole made will prevent the maintenance of the proper pressure. For this reason the third system, such as is used on the U. S. D9-A, is replacing the second.

In system (3) a gage is connected in the line running from the gasoline pump to the carburetor and indicates the pressure at which the gasoline is forced from the tank. There is a pressure relief valve between the pump and the gage, which may be adjusted so the pressure never exceeds a certain value, say 4 lb. (sq in.).

A sufficient pressure, either air or gasoline, is vital for the flow of gasoline to the carburetor and for the successful performance of the motor, so a gage is necessary to warn the pilot of a dangerous falling off of pressure. A gage also serves a useful purpose by indicating a too-high pressure, which might burst the tank. This would occur if the pressure relief valve failed.

At the present time there are two designs of air-pressure gages in use. The first, Fig. 1-A (see Specification No. 27004-C), has a range of 0 to 10 lb (sq in.). The second, Fig 1-B (see Specification No. 27060-A), has a range of 0 to 6 lb (sq in.). The second design is used both as an air-pressure gage and as a gasoline-pressure gage, the only difference being in the lettering on the dial and the form of the case. The internal mechanism is the same for each. There are two types of the 10-lb. gage—type A, manufactured by the National Gage & Equipment Co., and type B, manufactured by the U. S. Gage Co.—and one type of the 6 lb. gage, type D, manufactured by the National Gage & Equipment Co. All types are essentially the same in design and are of the Bourdon type of gage, similar to steam-pressure gages.

The details of construction are shown in Fig. 2. The Bourdon tube a, is made of seamless drawn bronze, of elliptical cross section, and bent into an arc of more than 180 deg. One end of the tube is closed, the other soldered to a hollow casting b, which serves both as a mounting for the Bourdon tube and a socket projecting through the case, to which the air line or gasoline line is connected. The free closed end of the Bourdon tube is connected to a sector gear c, which engages a pinion d, which is on the same shaft as the pointer. By this mechanism the motion of the free end of the tube is transmitted to the pointer and at the same time magnified. The hairspring takes up the lost motion between the gears and prevents back lash. Now, if the pressure inside the Bourdon

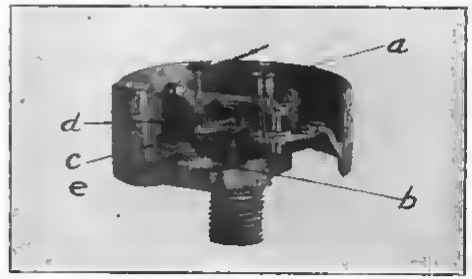


Fig. 2. Mechanism of Air-Pressure Gage

tube is made greater than atmospheric pressure, the tube tends to straighten out and the pointer is made to move over the scale. The tendency to straighten out is due to the fact that the increase in pressure pushes out the flattened sides of the tube so that the cross section becomes more nearly circular. This tends to equalize the lengths of the inside and outside walls, so that the curvature becomes less and the free end consequently moves out. This movement is directly proportional to the increase in pressure so that the scale is uniform. The specifications require that the error of the instrument should not be greater than 0.3 lb. (sq in.) at any point of the scale.

Only general instructions can be given regarding the installation, since the system of feed will vary considerably with the airplane. Specifications should be furnished with the engine or the airplane regarding the location and method of connecting. For example, in the JN-4H, JN-6H, and the DeH-4 the air-pressure gage is mounted on the instrument board, while in the U. S. D9-A the gasoline-pressure gage is mounted on the top of the gasoline tank. However, the following precautions should be noted:

(1) The union between the instrument and the air line or gasoline line should be air-tight, as should be all the joints and unions.

(2) Do not make sharp bends or kinks in the connecting tubes.

(3) This instrument, as all others, should be *securely* fastened to the instrument board, using the bolts, nuts, and lock washers furnished with the instrument.

The life of the instrument should be indefinite, barring accidents. A great overpressure or an accumulation of dust in the instrument may render it inaccurate. If any doubt should arise as to its accuracy, it should be sent to an instrument shop for examination and repair.

Oil-Pressure Gage

The purpose of this instrument is to indicate the pressure in the oil system of the engine. From the reading of the gage the motor mechanics or pilot may judge whether or not the flow is undisturbed and that the engine is receiving a generous supply of oil. A drop in pressure generally indicates that there is a leak in the oil system and the supply has become

* Prepared in the office of the Director of Air Service.

more or less exhausted. A rise in pressure indicates a stoppage, so there is not a free circulation. The pilot should observe the gage occasionally and consider any serious variation of pressure from the proper value a warning of danger. The proper values are different for different types of engines and for the same type at different temperatures of the atmosphere. The pilot should know this value before making a flight.

Three types of oil-pressure gages will be found on airplanes, A, B, and D. The first two, type A (National Gage & Equipment Co.) and type B (U. S. Gage Co.), have a range of 0 to 100 lb. ——— Type D (manufactured by the National Gage & Equipment Co.) is the latest design, having a range of 0 to 120 lb. ——— The current specification (No. 27039 A) requires this larger range.

The details of construction are identical with those of the air-pressure gage and need not be described. The Bourdon tube is made of heavier material than in the air or gasoline gage, since the range of pressure is greater

The scale is marked off in intervals of $\frac{5 \text{ lb.}}{\text{sq. in.}}$ and the reading may be estimated to the nearest $\frac{1 \text{ lb}}{\text{sq. in.}}$. Specifications limit the error to $\frac{3 \text{ lb}}{\text{sq. in.}}$ at any point of the scale.

Specifications for any engine should include a provision for the connection of a gage in the oil system, so no specific instructions need be given. The same general precautions should be followed as in the installation of the air or gasoline pressure gages.

Phenix Fireproof Dope

The improvements made in airplanes during the last six years to make them mechanically and aeronautically safer have been mainly constructional.

One detail which until recently has not kept pace with the other safety improvements in aircraft work is the dope for varnishing the cloth covering the wings, tail members and fuselage. The one great, though usually suppressed source of fear and trouble in aircraft flying has been the fear of fire.

The nature of the materials used in the manufacture of dopes for the past ten years has been the source of their great inflammability and when a fire starts on a machine it is almost certain to spread over the entire wing and tail surfaces burning all the supporting surfaces from under the aviator, with no chance of saving himself.

It was with these facts in mind that Nelson S. Hopkins, President of the Phenix Aircraft Products Company, of Williamsville, N. Y., developed the Phenix Fireproof Dopes and doping methods to produce a thoroughly practical and reliable fireproof dope for aircraft work, both for the airplane and dirigible.

During the past year at many places Mr. Hopkins showed the films and cloth doped with Phenix Fireproof Dope which aroused a great amount of interest and favorable comment. These Phenix Fireproof Dopes are the result of experimental work started over five years ago when developing the nitrate and acetate dopes after the supply of doping material from Europe was shut off by the War.

Phenix Dopes have a cellulose base but the active materials to produce the fireproofing properties are dissolved in the solution and not an added fire-resisting pigment which settles, giving a variable result with greatly increased weight. The dopes from the top of the barrel, or can, are as fireproof as those from the bottom. They are not a paint. The added weight over that of six coats of clear nitrate or acetate dope runs from 1½ to 2 ounces per square yard.

With Phenix Dopes it is not necessary to have an inner envelope or covering or doped cloth under the cap strip which increases the weight.

Phenix Fireproof Dope must be applied to new and undoped cloth to obtain the non-inflammable properties; they cannot be used with or in connection with the usual dopes and still retain the non-inflammable properties, neither can they be applied over other dopes.

Phenix Doping Methods are based upon the plan that the cloth or fabric is first fireproofed and then every layer of dope that is applied is fireproofed of itself so that the resultant fabric is absolutely fireproofed at every step as well as when completed.

In detail the cloth is first fireproofed by thoroughly saturating the linen or cotton cloth with Phenix Fireproofing Solution No. 152 when stretched over the frame, or preferably in a wooden tub before covering, and after thoroughly drying the cloth to apply three to six coats of Phenix Fireproof Dope Clear, No. 125. For a Clear Dope finish six coats of Clear Dope is used. For those desiring a longer life the use of three coats of Phenix Fireproof Aluminum Dope No. 123, over three coats of Clear Dope, is very highly recommended. Phenix Dopes work as well on cotton as on linen and are shipped already mixed ready for using.

Phenix Fireproofing Solution can also be used to great advantage for fireproofing parachutes and cloth flying suits, as there is no tendency for the flame to spread should the parachute or suit be exposed locally to the direct flame.

The Phenix Fireproofing Doping Methods, especially the Aluminum Finish, can be used to great advantage for the doping of the outer covering of dirigibles as it gives a fine appearance and a fireproof or non-inflammable surface.

New Aluminum Solder Successful

The difficulties encountered in attempting to solder aluminum are familiar to all who have experimented with the multitude of so-called aluminum solders which have appeared within the last few years. One of the chief sources of annoyance has been the tendency for electrolytic corrosion to set in at the joint, the aluminum being corroded, since the components of these solders are electro negative to aluminum. This difficulty has been successfully met and a new solder, the components of which are located so close to aluminum in the electro-chemical series that electrolytic action is rendered negligible, has been placed on the market by the Rohde Laboratory Supply Co. of New York City.

This material—which is called "Al-Solder"—is applied at a temperature of about 500 to 600 deg. Fahr. so that warping and other mechanical disturbances are avoided. After a moment's heating, an exothermic reaction takes places with the formation of an alloy. Since an alloy is formed with the aluminum, the durability of the joints is permanent and the seams can be made invisible by polishing, which is very desirable in instrument work, etc. Furthermore the joint may be reheated without injury so that an additional piece may be joined on without any trouble.

London-Paris-Strasburg-Prague Air Route

It is now possible not only to send letters and samples but also goods by air to Strasburg and Prague via Paris. In view of the important relations which exist between Great Britain and these cities the following particulars relating to the air services will doubtless be of value.

Airplanes leave Paris daily for Strasburg at 8 30 a. m. and the time taken on the flight is 2½ hours. Every Monday, Wednesday and Friday the machines are linked up with the airplane which continues the journey to Prague reaching that city 3 hours later, there being interval of half-an-hour at Strasburg so that the whole distance between Paris and Prague is covered in six hours. The return flights from Prague take place every Tuesday, Thursday and Saturday at 8 30 a. m. connecting up with the Paris machines at Strasburg.

It is intended to convert the tri-weekly flights from Strasburg to Prague into a daily service in the near future. The machines in use on the service are of the limousine type with a small cabin comfortably fitted for passengers, the engine being of 370 hp. The fare for passengers from Paris to Strasburg is 500 francs single, 800 francs return. Freight for goods 10 francs per kilo. Postal rates as usual, plus an air fee of 75 centimes up to two thirds of an ounce. There is a motor service for the convenience of passengers between aerodromes and the cities referred to.

The German Aircraft Industry*

By Edward P. Warner

The aircraft industry in Germany has almost ceased to exist, so far as construction is concerned, new building being forbidden under the terms of the treaty. A good deal of building of new airplanes and remodelling of military machines for commercial purposes, however, went on between the time of the armistice and the going into effect of the stipulations of the treaty, and the machines produced at that time are now being used to some extent. Although a number of airplane transport companies are doing business regularly, the Zeppelin line has been discontinued. This line operated the Nordstern, and also the Bodensee, which has been redesigned to carry more passengers.

A single agency in Berlin is booking passages by eight different lines, Albatros, Junkers, Rumpler, Sablatnig, Hawa, Balag, Dansk Luft Express, and Wiener Fluggesellschaft. Regular trips have been made from Bremen as a center to Berlin, Hamburg, Wesgeroog, Norderney, Borkum and Sylt, as well as between Berlin and Warnemunde and Berlin and Leipzig. The fares are moderate, the charge from Berlin to Leipzig during the Leipzig festivals having been only 800 marks ($1fi 00 for about 125 miles).

The only aircraft factories that I visited during my brief stay in Germany were those of the Junkers and the Zeppelin airship companies. A number of the other builders, although unable to do anything at the present time, are reported to be carrying on experiments on aircraft elements and keeping their shops in shape to start work again as soon as the ban is lifted, this being especially true of the subsidiary Zeppelin companies at Seemoos (Dornier) and at Staaken (Rohrbach) and of the Rumpler and D. F. W.

The Junkers Factory

The works of the Junkers company are located at Dessau, about a mile to the south of the center of the city, the main factory where the engines are made, and the airplane factory being about a quarter of a mile apart. The airplane factory, which includes also the wind-tunnel and part of the general laboratory equipment, is a one-story building having about 25,000 sq. ft. of floor space. Twenty airplanes were in course of erection at the time of my visit, and I should estimate that there are 250 men employed on airplane construction. The machine tools are being worked up to their capacity and the whole plant has an air of intensive and efficient effort which is not common in Continental Europe at the present time.

The Junkers firm is making at the present time, only one type, the six-passenger all-metal monoplane so well known in America. The construction and alignment of the parts of these machines is taken care of by jigs instead of by individual fitting, thus assuring complete interchangeability. The wings, for example, are mounted on a jig representing the side of the fuselage with its fittings, a method which, while not at all rare, is not so universally applied as would be desirable and which is peculiarly easy to apply with an internally-braced airplane where all of the attachments and bracing are in a single unit and bear a definite relation to each other.

The corrugated duralumin covering for the wings is said to be 0 3 mm. in thickness, which is somewhat less than the thickness of the covering on the Junkers broken up at Mineola and examined by the Air Service. The spar tubes are about 60 mm. in diameter and the walls of the different tubes vary from 1 to 2 mm. in thickness. Up to the present time, it has been found impracticable to use a larger diameter than 60 mm. or a less wall thickness than 1 mm. in conjunction with that diameter, on account of the danger of local collapse of the wall. Each wing is fixed to the fuselage by nine screwed attachments, and the wings can be removed entire or replaced in fifteen minutes. The fittings are made of 60,000 lb. carbon steel.

The Junkers firm has a well-equipped testing laboratory for materials, but they are doing nothing themselves on the development of alloys, using the laboratory to check up on the suitability of the materials delivered to them. They say that the duralumin which they can obtain has considerably deteriorated in its weathering properties within the last few years, and that it is now essential to paint all exposed duralumin surfaces for protection, whereas a few years ago the duralumin which they were obtaining could be exposed for years without any protective coating and without any important deterioration.

The welding of duralumin thin sections is reported to be absolutely hopeless, no heat treatment restoring the original properties. In any case it is necessary to heat-treat after rolling the sections. The Junkers people claim to have very little confidence in steel construction for airplanes of small or moderate size. Although their first all-metal machine, a single-seater, was built entirely of steel and iron, they found it excessively heavy and apparently have an intention of returning to that method.

Seaplanes of a type practically identical with the land machine except for the addition of floats are also being built. The floats are all duralumin, with flat bottoms and parallel sides and a single step and three bulkheads dividing each float into four water tight compartments, and the method of frame construction employs a combination of tubes and rolled sections in much the same manner as does the wing.

Aside from the wind-tunnel, which has been described in another report, there is nothing very new about the Junkers laboratory. The director tells me that they find impact testing of metallic materials very useful, and it would certainly appear, in view of its extended employment everywhere else in the world, that this method should find a wider application in America than it has done as yet.

The Zeppelin Factory

The Zeppelin Airship company's factory is located on the outskirts of Friedrichshafen. The equipment comprises two or three good-sized factory buildings, the new laboratory, two airship sheds and a flying field. At the present time no construction is going on, the men who have been retained being engaged in clearing up old stock and in making other aluminum goods than airships, but the managers of the company are all set to go the minute that new construction or the operation of an airship transportation line on a large enough scale to be worth their while is permitted, and they are seeking orders in all directions. I have seen no other firm anywhere in Europe so optimistic about the immediate prospects of aerial transportation and their own share therein. At present the company employs two hundred men, a reduction from four thousand during the war.

The airship sheds are now occupied by the Nordstern and the Bodensee, without their gasbags in place. The Nordstern has never been inflated.

The Zeppelin people speak with some disdain of the making of elaborate stress calculations for rigids. They say that this may be all right at first but that the stresses are too complex and uncertain for such treatment and that design must ultimately depend on empirical rules and on the result of accumulated experience, and they lay great emphasis on their own favorable position in respect of such experience by comparison with anyone starting anew. Airship building, of course is unlike airplane work in that practically nothing has been written on it.

What the Zeppelin company have learned is their secret, and the British had to start again from the ground, and had to depend much more on fundamental theory than the Germans had ever done, as the British were trying to begin their work far up on the ladder of progress, invoking mathematical analysis to enable them to omit many of the rungs by which the Germans had climbed. The Germans attribute the success of their ships in large part, too, to the skill of the workmen whom they have trained, claiming that no other nation or company has fabricated such light aluminum sections with the same success.

* Report prepared for the National Advisory Committee for Aeronautics.

Kentucky Companies Buying Ships

Several towns in Kentucky have organized flying schools and have purchased from one to three airplanes through private enterprises during the last month. Lexington is organizing a $20,000 company composed of business men of that city. They plan to purchase two ships and will maintain a training school for students and establish a fully equipped station for inter-city traffic to surrounding points in the Blue Grass region of the state. Other towns that have organized similar companies are Barbourville, Pineville and Middlesboro Each of these has purchased one ship and is giving considerable attention to the training of aviators. The movement is taking great hold as a fad, but it is confidently expected to develop into something substantial.

In Lexington an excellent four-way field located on one of the famous Blue Grass farms, close to the city, has been donated for use of the company. A Lexington refinery will install a gas filling tank on the field and a repair shop will be opened for the patronage of transient planes Other ships will be purchased when present plans to establish a complete circuit for field schedules mature.

C. F. Dunn, secretary of the Lexington Board of Commerce, and other officials of that organization, are actively behind the project of a training school in their city In speaking of the proposed school, Mr Dunn had this to say

"Lexington is already known through this country and even across the waters as a great racing center. We now propose to make it famous not only as a stamping ground of thoroughbred race horses, but as a first class center for the new and ever increasing sport and business of flying Airplanes have come to stay in Lexington."

Anti-Aircraft Battery Tests

Accurate data on the timing of anti-aircraft shells are reported as a result of Air Service cooperation with anti-aircraft battery commanders at Fort Monroe, in tests held recently In these tests Army aviators flew over a prescribed course at various altitudes while the anti-aircraft guns fired at points within 400 or 500 yards of them, the airplane observers reporting as to whether the bursts of the shrapnel occurred above or below the level of the airplanes. The radio telephone was used and at the battery commander's direction the pilot promptly reported his observations as to the bursts. This was said to have been the first instance of cooperation between aircraft and anti-aircraft battery firing in the history of the Service. The results have been reported as entirely satisfactory.

Eddie Stinson Buys Dixie Flying Field

The Dixie Flying Field, Birmingham, Ala., has been taken over by Eddie Stinson and will be made the permanent headquarters of a flying school Negotiations are in progress to make Birmingham the Southern headquarters for Curtiss airplanes and equipment. Announcement to this effect was made by the aviation committee of the Chamber of Commerce.

Mr Stinson will start his school at once. The equipment will consist of three Curtiss planes Equipment valued at $20,000 already has been ordered for the school. S B Irwin and R. C. McMurray, two well-known pilots, will assist Mr Stinson.

Eddie Stinson has been in the air a total of more than 8,000 hours.

London-Amsterdam Winter Service

Owing to the inadequate provision of suitable ground organization for air navigation under winter conditions prevailing over Holland and the Belgian Coast it has been found necessary to suspend the direct air service to Amsterdam. Meanwhile, there is a rapid service to Amsterdam via Brussels. Passengers leaving Cricklewood by air at 12·30 p. m. are able to secure the railway connection from Brussels to Holland reaching Rotterdam, The Hague and Amsterdam on the same evening Arrangements are being made for the conveyance of freight by the same route.

Wallace Field, Iowa, Progress

An all-year emergency service will be maintained at the Wallace Field, Davenport, Iowa, according to announcement by Manager Wallace. The service will be for the special accommodation of doctors who have emergency calls for country patients or to nearby towns, for professional men and business men who are summoned for emergency affairs.

The hangar accommodates four airplanes and is a building 180 x 32 ft. with a solid concrete foundation. Tents on the grounds accommodate two other machines at the field.

E H Jenkins, a traveling salesman, has written from Chicago for accommodations for his plane which he plans to store there this winter

Manager Wallace calls attention to the fact that while approximately 500 people rode in the airplanes at Wallace Field the past season there was not a single approach to a serious accident at any time passengers were in the machines.

Maintenance of German Aerodromes

The Berlin correspondent of Handley Page, Ltd., reports that the Inter-allied Aviation Commission appointed under the Treaty of Peace, has consented to waive the destruction of the following military aerodromes:—Breslau, Gandau, Brunswick, Fuerth, Grossenhain, Hamburg, Paderborn, Schleusheim, Deveau, Nr Conigsberg The following seaplane stations are also included —Kiel, Holtenau, Norderney, Warnemende, and Lift, as well as the Airship harbors of Nordholz, Seddin, Friedrichshafen-Loewenthal, and Bodan-Oos. Fifteen per cent of the privately owned aviation buildings which were used for Military purposes during the War are also to be left standing With very few exceptions the airship halls are to be pulled down in accordance with the provisions of the Treaty of Peace.

N. Y. Naval Reserve to Have Airplane

According to advice received from the Navy Department, a Macchi-Nieuport type, 160 hp seaplane, equipped with dual controls for instructive purposes, will be sent to the Somerville station of the Naval Militia early next spring This machine will be in charge of the Aviation section, Third Battalion, New York Brigade of the United States Naval Reserve Force, and will be for the purpose of giving men anxious to learn something about flying an opportunity to do so without enlisting in the regular navy

Illinois University to Study Aviation

Arrangements have been completed with the war department for the establishment of an air unit at the University of Illinois in connection with the military training department. A laboratory for the ground school and planes, engines, aerial cameras and wireless outfits will be provided by the government, with competent instructors. Illinois is one of the five universities to receive such outfits.

University of Wisconsin Wants Airplane

An airplane may soon be purchased by students at the University of Wisconsin. The University Aero Club, organized by a number of ex-army and navy aerial officers last spring decided recently to begin raising money to buy an airplane. The end toward which they are working is to establish a flying department in the university military organization.

Bleriot Mammoth Carries Large Load

The aviator Casale has been flying the giant Bleriot Mammoth recently. He has made flights carrying useful load of 7200 pounds and reached an altitude of 6000 feet. The present record for altitude with large loads is held by the four-engined Handley Page. The Mammoth will be entered in the French Government competition for large machines.

Rome-Berlin Service Projected

According to the *Lokal Anzeiger* the Rumpler Co. has approached the Italian Government with a proposition to run an airway from Rome to Berlin by way of Verona and Monaco. It is likely that this service will be instituted in the near future.